International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

M.3041

(02/2020)

SERIES M: TELECOMMUNICATION MANAGEMENT, INCLUDING TMN AND NETWORK MAINTENANCE

Telecommunications management network

Framework of smart operation, management and maintenance

Recommendation ITU-T M.3041

ITU-T M-SERIES RECOMMENDATIONS

TELECOMMUNICATION MANAGEMENT, INCLUDING TMN AND NETWORK MAINTENANCE

Introduction and general principles of maintenance and maintenance organization	M.10–M.299
International transmission systems	M.300–M.559
International telephone circuits	M.560–M.759
Common channel signalling systems	M.760–M.799
International telegraph systems and phototelegraph transmission	M.800–M.899
International leased group and supergroup links	M.900–M.999
International leased circuits	M.1000–M.1099
Mobile telecommunication systems and services	M.1100–M.1199
International public telephone network	M.1200–M.1299
International data transmission systems	M.1300–M.1399
Designations and information exchange	M.1400–M.1999
International transport network	M.2000–M.2999
Telecommunications management network	**M.3000–M.3599**
Integrated services digital networks	M.3600–M.3999
Common channel signalling systems	M.4000–M.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T M.3041

Framework of smart operation, management and maintenance

Summary

Recommendation ITU-T M.3041 introduces a framework of smart operation, management and maintenance (SOMM). In this Recommendation, characteristics, scenarios and the functional architecture of SOMM are provided to support service operation, network management and infrastructure maintenance for both traditional non software-defined networking/network function virtualization (non-SDN/VFN), and SDN/NFV aware networks. This Recommendation also describes the relationship of the functional architecture of SOMM with the logical layered architecture (LLA) of a telecommunications management network (TMN).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T M.3041	2020-02-13	2	11.1002/1000/14181

Keywords

Maintenance, management, operation, smart.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T M.3041

Framework of smart operation, management and maintenance

1 Scope

This Recommendation provides the framework of smart operation, management and maintenance (SOMM). It describes the characteristics, scenarios and the functional architecture of SOMM to support service operation, network management, and infrastructure maintenance for both traditional non-SDN/NFV and SDN/NFV aware networks.

This Recommendation also describes the relationship of the functional architecture of SOMM with the logical layered architecture (LLA) of a telecommunication management network (TMN).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T M.60] Recommendation ITU-T M.60 (1993), *Maintenance terminology and definitions*.

[ITU-T M.3010] Recommendation ITU-T M.3010 (2000), *Principles for a telecommunications management network.*

[ITU-T M.3040] Recommendation ITU-T M.3040 (2019), *Principles for on-site telecommunication smart maintenance.*

[ITU-T M.3400] Recommendation ITU-T M.3400 (2000), *TMN management functions*.

[ITU-T Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network.*

[ITU-T Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 logical layered architecture [ITU-T M.3010]: An architectural concept that organizes the management functions into a grouping of management layers and describes the relationship between the layers.

3.1.2 management function [ITU-T M.3010]: The smallest part of a management service as perceived by the user of the service.

3.1.3 management function set [ITU-T M.3010]: TMN management function set is a grouping of TMN management functions that contextually belong together, i.e., they are related to a specific management capability (e.g., alarm reporting functions, traffic management control). The TMN management function set is the smallest reusable item of functional specification. The TMN

management function set must be considered as a whole. It is similar to the requirements part of the OSI SMF (system management function).

3.1.4 management service [ITU-T M.3010]: A management service is an offering fulfilling specific telecommunications management needs.

3.1.5 network slice [ITU-T Y.3100]: A logical network that provides specific network capabilities and network characteristics.

3.1.6 operations system [ITU-T M.3010]: A physical block which performs operations systems functions (OSFs).

3.1.7 operations systems function (OSF) [ITU-T M.3010]: A function block that processes information related to the telecommunications management for the purpose of monitoring/coordinating and/or controlling telecommunication functions including management functions (i.e., the TMN itself)

3.1.8 orchestration [ITU-T M.60]: Sequencing where a management operation is dependent upon several managed objects in a network being changed in a strict sequence.

3.1.9 q reference points [ITU-T M.3010]: A reference point located between NEF and OSF, between QAF and OSF, and between OSF and OSF.

3.1.10 software-defined networking [ITU-T Y.3300]: A set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner.

3.1.11 telecommunication smart maintenance [ITU-T M.3040]: The maintenance carried out with advanced technology-based (IoT, AR, wearable technology, etc.) toolkit and system, which can provide strong human-computer interaction capabilities and online guidance to personnel, to achieve higher efficiency and precision of actions.

3.1.12 x reference points [ITU-T M.3010]: A reference point located between OSF function blocks in different TMNs.

NOTE – Entities located beyond the x reference point may be part of an actual TMN (OSF) or part of a non-TMN environment (OSF-like). This classification is not visible at x reference points.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AR	Augmented Reality
DevOps	Development Operations
DM-OSF	Data Convergence and Management Layer – Operations Systems Function
EMS	Equipment Management System
E-OSF	Element Management Layer – Operations Systems Function
FCAPS	Fault, Configuration, Accounting, Performance, and Security
IoT	Internet of Things
IM-OSF	Infrastructure Management Layer – Operations Systems Function
IT	Information Technology

LLA	Logical Layered Architecture
MANO	Management and Orchestration
MS-OSF	Management Service Layer – Operations Systems Function
NE	Network Element
NEF	Network Element Function
NFV	Network Function Virtualization
NMS	Network Management System
N-OSF	Network Management Layer – Operations Systems Function
OAM	Operations, Administration and Maintenance
OS	Operations System
OSF	Operations Systems Function
OSI	Open Systems Interconnection
PaaS	Platform as a Service
QAF	Q Adapter Function block
SDN	Software-defined Networking
SA-OSF	Scenario Application Layer – Operations Systems Function
SMF	System Management Function
SOMM	Smart Operation, Management and Maintenance
S-OSF	Service Management Layer – Operations Systems Function
TMN	Telecommunication Management Network

5 Conventions

None.

6 Introduction

This Recommendation presents scenarios and functional architecture of smart operation, management and maintenance (SOMM), which is to support service operation, network management, and infrastructure maintenance for both traditional non software-defined networking (SDN)/network function virtualization (NFV) networks and SDN/NFV aware networks.

The objective of the SOMM framework is to extend the traditional logical layered architecture (LLA) of [ITU-T M.3010] by introducing new layers and operations systems functions (OSFs) to support a wider variety of telecommunication management activities for the integrated network, and to support rapid deployment of complicated operations systems (OSs) based on open services and convergent data.

With the rapid evolution of network and information technology (IT), the main characteristics of the SOMM framework can be described as follows:

– **Intelligent**: Based on big data, artificial intelligence (AI) algorithms and smart devices, the OSs in a SOMM framework can perform management and maintenance work instead of humans in a more precise and easier way, and can even give predictive judgements on network or service failures.

– **Data driven**: A SOMM framework converges masses of data from different OSs to a unified data model, supporting data sharing, data mining, data correlation, machine learning and other usage intents.
– **Integrated**: A SOMM framework can be applied for current and future networks. It can also support cross-domain management activities to fulfil end-to-end services for customers.
– **Agile**: A SOMM framework is a service-oriented architecture in which each operations systems function (OSF) is packaged as a service to be opened. A new OS can be deployed quickly with these open services and convergent data, along with the common infrastructure platform for OSs.

Typical application scenarios of a SOMM framework are presented in clause 7.

7 Scenario classification of SOMM

Some typical application scenarios of SOMM are listed in Table 1. It should be noted that the scenarios listed in the table are typical ones, and that these do not cover all the possibilities. Any possible scenario that can be classified into these types should also be supported by SOMM.

The scenarios of SOMM could be classified into five types which are smart operation, smart management, smart maintenance, smart comprehensive analysis and traditional operations, administration and maintenance (OAM).

Table 1 – Scenario classification of SOMM

1) Smart operation scenarios
i. Customer service support
ii. End-to-end service provision and operation
2) Smart management scenarios
i. Synergy management of multi-tech networks ii. Smart network monitoring
3) Smart maintenance scenarios
i On-site telecommunication smart maintenance
4) Smart comprehensive analysis scenarios
i. What-if analysis
ii. Big data analysis
5) Traditional OAM scenarios

7.1 Smart operation scenarios

7.1.1 Customer service support

Typical scenarios of customer service support include malfunction complaint pre-treatment, large area fault interception of customers, end-to-end service fault processing and customer-specific network monitoring.

7.1.2 End-to-end service provision and operation

End-to-end service provision and operation can occur in the situation of cross-vendor, cross-domain cases, which is an important way to achieve the closed-loop operation and the quality of service for customers through operation processes.

7.2 Smart management scenarios

7.2.1 Synergy management of multi-tech networks

Typical scenarios of synergy management of multi-tech networks currently include cloud and network synergy management and 5G network slice management.

In the cloud and network synergy management scenario, unified orchestration of network and cloud resources are needed to support cloud and network convergent services be deployed and fulfilled quickly on customer's demands.

5G network slice management is another typical synergy management scenario. 5G network slicing management occurs among multi-layer and multi-domain networks, in which different technologies are used. To realize an end-to-end slice management, orchestration of different slice segments should be supported.

7.2.2 Smart network monitoring

Typical scenarios of smart network monitoring include daily operation monitoring for networks and services in an end-to-end view. In addition, operation monitoring under the cases such as critical incidents, natural disasters, and emergency communication scenarios are also included.

7.3 Smart maintenance scenarios

7.3.1 On-site telecommunication smart maintenance

Typical scenarios of on-site telecommunication smart maintenance include on-site patrol, on-site overhaul, on-site troubleshooting and activating new services such as installation and configuration of home gateway. These maintenance activities can be carried out with advanced technology-based (IoT, AR, wearable technology, etc.) toolkit and system [ITU-T M.3040].

7.4 Smart comprehensive analysis scenarios

7.4.1 What-if analysis

SOMM can provide cross-layer and cross-domain operation and management, making smart what-if analysis possible. Smart what-if analysis can perform failure simulation, network capacity expansion simulation, throughput simulation, etc. Smart what-if analysis is carried out off-line, and AI prediction can be used in what-if analysis.

7.4.2 Big data analysis

SOMM can support big data analysis for different applications based on convergent data with the use of data collecting, data processing, data modelling, data mining and machine learning technologies, assisting operators to better realize the value of data.

7.5 Traditional OAM scenarios

Traditional OAM scenarios include the telecommunication traditional business management, service management, network management and element management activities of [ITU-T M.3010].

8 Functional architecture of SOMM

This clause first introduces the top-view of SOMM for integrated networks in clause 8.1. Then clauses 8.2 and 8.3 describe layered functional architecture of SOMM.

8.1 Top-view of SOMM for integrated network

The SOMM framework needs to support integrated networks, including SDN/NFV aware networks and non-SDN/NFV networks, as is shown in Figure 1.

The SOMM system includes network management system (NMS)/ equipment management system (EMS) which is used for the management of non-SDN/NFV networks. The SOMM system also includes software-defined networking (SDN) orchestrator/controller, network function virtualization (NFV) management and orchestration (MANO) for the management of SDN/NFV aware networks.

SDN aware networks and NFV aware networks can be managed by SDN orchestrator/controller and NFV MANO separately, or by a unified orchestrator jointly.

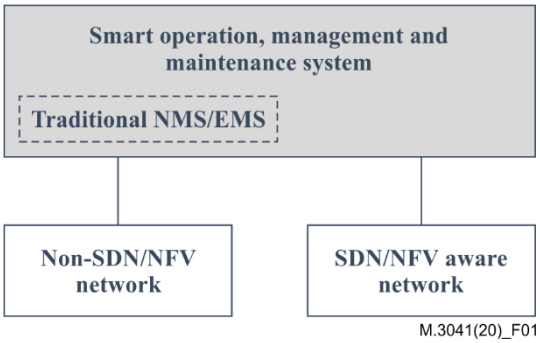

Figure 1 – Top-view of smart operation, management and maintenance system

8.2 Layered functional architecture of SOMM

The layered functional architecture of SOMM has extended the traditional logical layered architecture (LLA) of [ITU-T M.3010] by introducing new layers and OSFs to support a wider variety of telecommunication management activities for the integrated network, and to support rapid deployment of complicated OSs based on open services and convergent data.

Figures 2 describes the layered functional architecture of SOMM, including scenario application layer, management service layer, data convergence and management layer and infrastructure management layer.

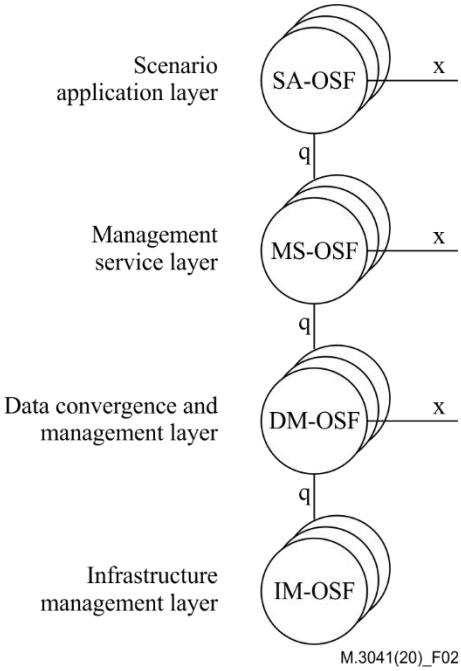

Figure 2 – Layered functional architecture of SOMM

Scenario application layer: This layer mainly includes the typical and emerging operation maintenance scenarios summarized in clause 7 which includes smart operation, smart management, smart maintenance, smart comprehensive analysis and traditional business-level OAM. The OS of this layer accesses information and functionality in the other layers.

Management service layer: This layer incorporates the capacity of fundamental functions of OSs which can be packaged as different services to be opened to scenario application layer. The management services of this layer include traditional telecommunication service management, network management and element management functions, as well as the orchestration functions, etc.

Data convergence and management layer: This layer provides data-driven ability for SOMM and converges mass of data from different OSs to unified data model, supporting data sharing, data mining, data correlation, machine learning and other usage intents. Data in this layer can be opened to support management service layer and scenario application layer.

Infrastructure management layer: This layer is the operational foundations for SOMM. The infrastructure could possibly be based on physical servers or cloud, and platform as a service (PaaS) components providing IT services can also be included to support rapid deployment of OSs in SOMM.

Each layer described above may consist of different operations systems functions (OSFs) as outlined in [ITU-T M.3010], and will be explained further in clause 8.3. In order to distinguish the layers, a different type of OSF is used for each one as follows:

1) OSF in the scenario application layer is SA-OSF;
2) OSF in the management service layer is MS-OSF;
3) OSF in the data convergence and management layer is DM-OSF;
4) OSF in the infrastructure management layer is IM-OSF;

In Annex A, the relationship between the LLAs of [ITU-T M.3010] and this Recommendation is described in detail for comparison.

The q and x reference points defined in [ITU-T M.3010] also exist in SOMM.

8.3 Sub-functions in layered functional architecture of SOMM

Figure 3 outlines the sub-functions in the layered functional architecture of SOMM.

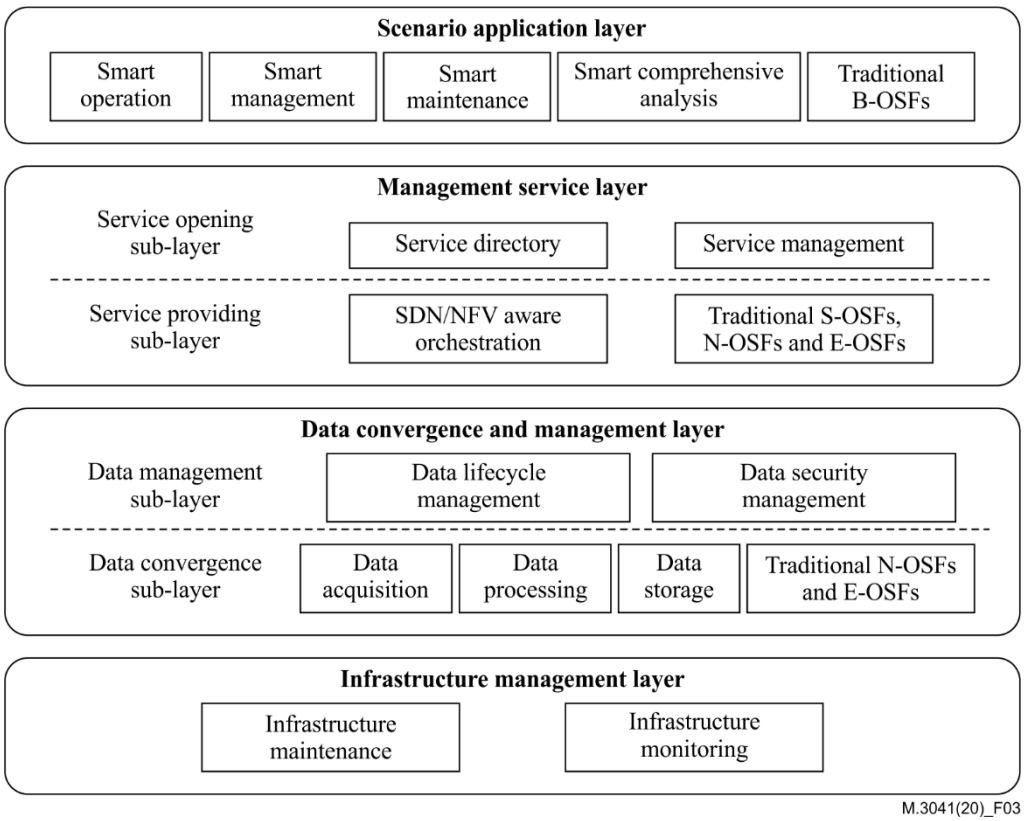

Figure 3 – Sub-functions in layered functional architecture of SOMM

8.3.1 Scenario application layer

The scenario application layer consists of five management function sets as follows, all supported by data and services from lower layers.

1) Smart operation – This management function set mainly includes a group of OSFs which are used to support application of scenarios such as customer service support scenarios and end-to-end service provision and operation scenarios. The related scenarios are described in clause 7.1.

2) Smart management – This management function set mainly includes a group of OSFs which are used to support application of scenarios such as synergy management of multi-tech networks scenarios and smart network monitoring scenarios. The related scenarios are described in clause 7.2.

3) Smart maintenance – This management function set mainly includes a group of OSFs which are used to support efficient and precise maintenance activities with advanced technology. The related scenarios are described in clause 7.3.

4) Smart comprehensive analysis – This management function set mainly includes the OSFs which are used to support kinds of simulation analysis and big data analysis scenarios. The related scenarios are described in clause 7.4.

5) Traditional B-OSFs – This management function set mainly includes a group of traditional business management functions which are aimed at supporting the decision-making process for the optimal investment and use of new telecommunications resources, supporting management of OAM related budget, supporting the supply and demand of OAM related manpower and maintaining aggregate data about the total enterprise [ITU-T M.3010]. The related scenarios are described in clause 7.5.

8.3.2 Management service layer

Management service layer includes two sub-layers.

8.3.2.1 Service opening sub-layer

Service opening sub-layer includes the following management function sets:

1) Service directory – This management function set is required to establish and maintain a directory for all the abilities of services opened to the upper scenario application layer's OSs.

2) Service management – This management function set is required to monitor the performance and quality of the open services established in this layer, as while as troubleshooting and lifecycle management for these services.

8.3.2.2 Service providing sub-layer

All the services in the service directory of service opening sub-layer are provided by this layer. The service providing sub-layer includes the following management function sets:

1) SDN/NFV aware orchestration – This management function set is aimed at arranging and coordinating networks' resources to satisfy customers' demands for both physical and virtual infrastructures. It usually includes service orchestration and resource orchestration.

2) Traditional S-OSFs, N-OSFs and E-OSFs – In this management function set, there are traditional OSFs includes S-OSFs, N-OSFs and E-OSFs of [ITU-T M.3010] which are used to provide TMN management functions for traditional network, such as fault, configuration, accounting, performance, and security (FCAPS) management.

In both SDN/NFV aware orchestration and traditional S-OSFs, N-OSFs and E-OSFs management function sets, AI assistance in the form of advanced mathematical analysis and prediction in machine learning will be used to meet management needs, such as correlation analysis of alarming, automatic troubleshooting, and automatic fulfilment of service, etc.

8.3.3 Data convergence and management layer

Data convergence and management layer includes two sub-layers.

8.3.3.1 Data management sub-layer

Data management sub-layer includes the following management function sets:

1) Data lifecycle management – This management function set is aimed at managing the quality and model of data within a whole range of data processing phases.

2) Data security management – This management function set provides the ability for the authorization, authentication and audit management of data access, display and export. The encryption function for data transmission is also included.

8.3.3.2 Data convergence sub-layer

Data convergence sub-layer includes the following management function sets:

1) Data acquisition – This management function set provides various methods for collecting and adapting various data from all kind of network, terminals and infrastructure.

2) Data processing – This management function set provides different ways to handle the data, including data cleaning and tagging.

3) Data storage – This management function set provides the ability to save massive data in a distributed way in the cloud. Data copies are stored in multiple nodes, which can avoid data unavailability due to single machine failure or storage medium damage.

4) Traditional N-OSFs and E-OSFs – This management function set in the data convergence sub-layer contains only the data-related N-OSF and E-OSFs defined in [ITU-T M.3010], such as the ability to communicate with network elements or lower OSs.

8.3.4 Infrastructure management layer

Infrastructure management layer is aimed at managing the common infrastructure of OSs. These infrastructures are usually the cloud-based distributed infrastructures, they are physical foundations of SOMM. This management layer includes the following management function sets:

1) Smart infrastructure maintenance – This management function set provides both on-site and remote maintenance abilities for the infrastructure of OSs. New technologies such as IoT, AI and smart wearable technology can help to make the maintenance smarter.
2) Infrastructure monitoring – This management function set provides the ability to gather the alarm, performance, capacity and usage data of infrastructures continuously in a centralized way.

9 Development considerations of SOMM

With the introduction of development operations (DevOps) technologies and methods, the construction and continuous updates of SOMM systems could be more agile.

Since the framework of SOMM is a kind of open and loose-coupled structure, the OSs of each management function set in each layer of SOMM can be designed, developed, tested in the development environment. At this stage, the software of OS is in the development state. When the software of OS is released to the operation environment, it will be in the operation state.

The DevOps mode of SOMM is shown in Figure 4.

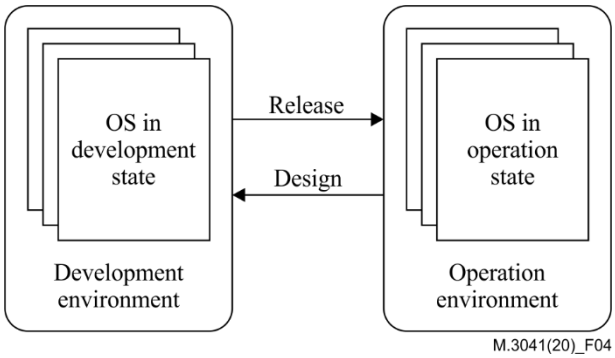

Figure 4 – DevOps mode of SOMM

Annex A

Relationship between the LLAs of [ITU-T M.3010] and this Recommendation

(This annex forms an integral part of this Recommendation.)

[ITU-T M.3010] defines the logical layered architecture (LLA) which organizes management functions into groupings called "logical layers", and each logical layer reflects particular aspects of management arranged by different levels of abstraction. The operations systems functions (OSFs) in each logical layer are known as B-OSF, S-OSF, N-OSF and E-OSF respectively as shown in Figure A.1.

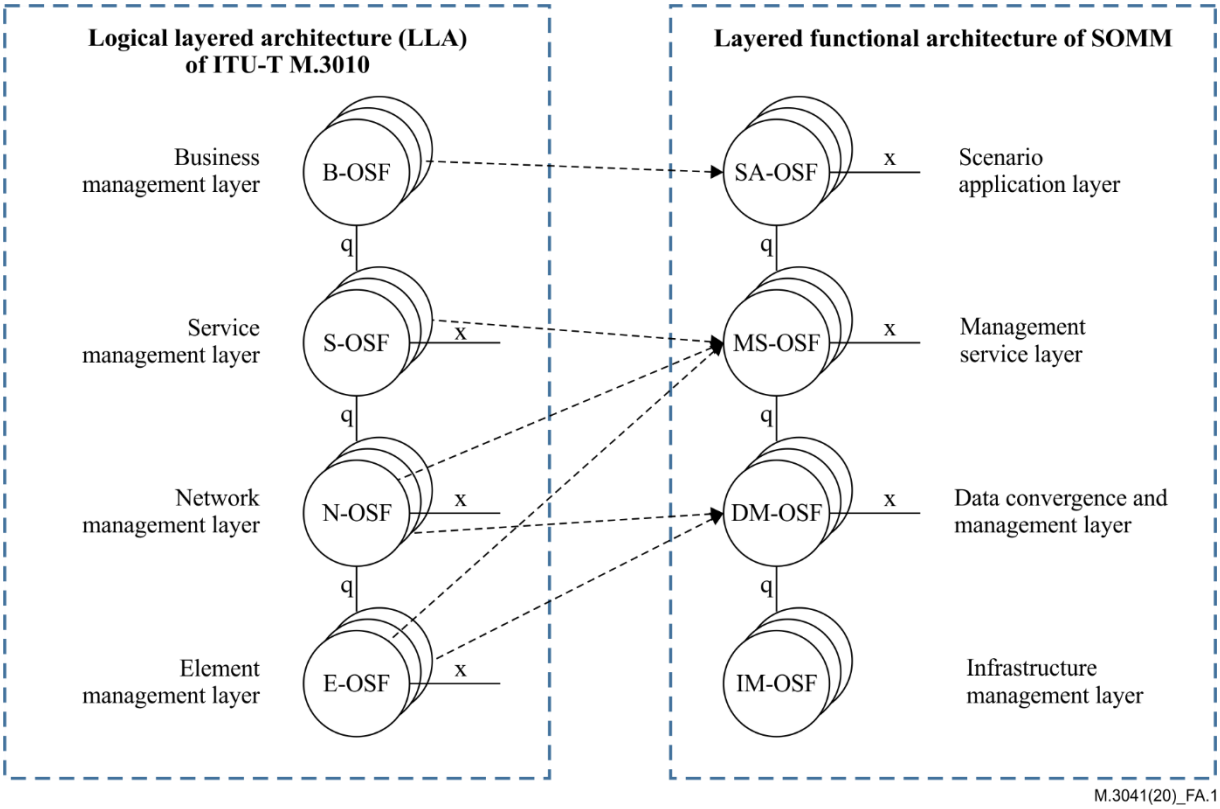

Figure A.1 – Relationship between the LLAs of [ITU-T M.3010] and this Recommendation

The relationship with LLA of [ITU-T M.3010] is illustrated in three aspects:

1) The functional architecture of SOMM is also within the scope of TMN and it can be treated as a re-organization of OSFs in LLA as well as extensions of LLA of [ITU-T M.3010] because it also introduced new functions when compared with [ITU-T M.3010].

2) The functional architecture of SOMM has a tight mapping relationship with the LLA of [ITU-T M.3010], as shown in Figure A.1. The mapping relationships are described as follows:
   - E-OSFs in element management layer are mapped to DM-OSFs in data convergence and management layer and MS-OSFs in the management service layer;
   - N-OSFs in the network management layer are mapped to DM-OSFs in the data convergence and management layer and MS-OSFs in the management service layer;
   - S-OSFs in the service management layer are mapped to MS-OSFs in the management service layer;

- B-OSFs in the business management layer is mapped to SA-OSFs in the scenario application layer;
- The functions in SOMM has a wider scope than in [ITU-T M.3010], The OSFs in SOMM includes but are not limited to those in the LLA of [ITU-T M.3010], because the framework of SOMM should support both traditional scenarios and new scenarios and it should also support both non-SDN/NFV networks and SDN/NFV aware networks.

3) In the functional architecture of SOMM, the q reference points and x reference points are also used to describe intra-communication between OSFs within one TMN and inter-communication between different TMNs respectively.

Data in SOMM are centralized and managed in a converged way, which includes both network element data and network data. In TMN, these data are usually collected and generated by EMS and NMS. Besides, all other manage-related data are within the scope of SOMM and should be managed in the data convergence and management layer.

It should be noted that "service" in SOMM refers to "management service" which is related to the opened network capacities opened. It should be clearly distinguished from "customer service".

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	**Telecommunication management, including TMN and network maintenance**
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2020